(12) UK Patent Application (19) GB (11) 2 088 159 A

(21) Application No 8135023
(22) Date of filing 20 Nov 1981
(30) Priority data
(31) 80/37221
(32) 20 Nov 1980
(33) United Kingdom (GB)
(43) Application published
3 Jun 1982
(51) INT CL[3]
H02J 7/00
(52) Domestic classification
H2H 21R BCD BCG
(56) Documents cited
None
(58) Field of search
H2H
(71) Applicant
Harmer & Simmons Limited,
Peregrine Road, Hainault, Ilford, Essex
(72) Inventor
Michael Allen Morling
(74) Agent
Jensen & Son,
8, Fulwood Place, High Holborn, London, WC1V 6HG

# (54) Battery Charging Apparatus

(57) A battery charging system is responsive to the internal impedance of the battery. A comparator (1) compares the actual battery voltage with a reference voltage (8) to terminate a first phase of charging when a pre-set voltage is reached. In a second phase, battery impedance, obtained by dividing battery voltage by battery output current, is in one embodiment compared with a fixed reference value (14), charging being terminated when a predetermined relationship between the actual value and the reference value is reached.

In another embodiment (Figure 2) the first value of impedance obtained is put in a store (13) and battery impedance is then determined at predetermined intervals. The new value is compared to the previous value held in the store and then the new value is inserted in the store. The second phase of charging is terminated when a predetermined relationship between the new value and the value held in the store is reached.

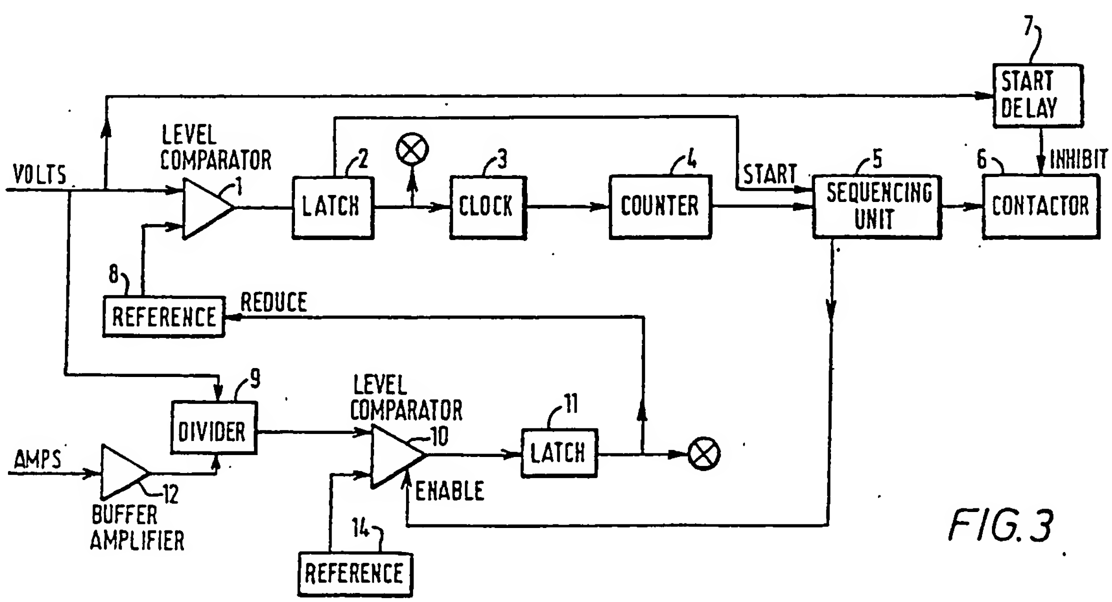


FIG.3

GB 2 088 159 A

FIG.1

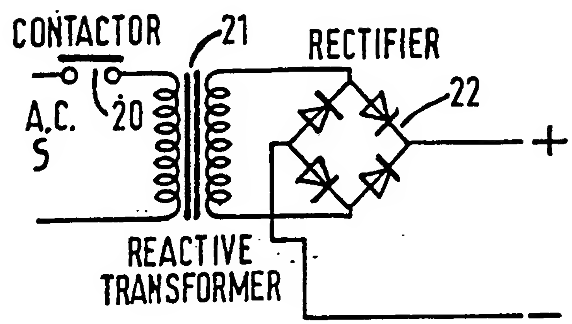
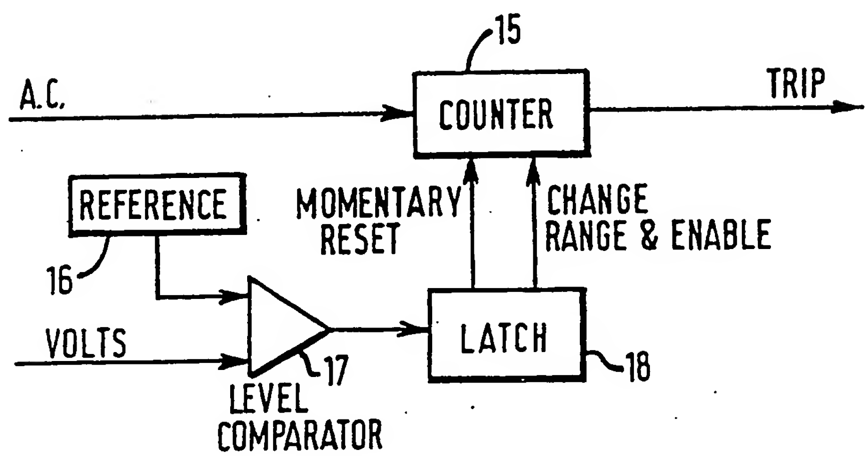

CONTACTOR
21
RECTIFIER
22
A.C.
S
20
+
REACTIVE
TRANSFORMER
−

FIG.4


15
A.C.
COUNTER
TRIP
REFERENCE
MOMENTARY
RESET
CHANGE
RANGE & ENABLE
16
VOLTS
LATCH
17
18
LEVEL
COMPARATOR

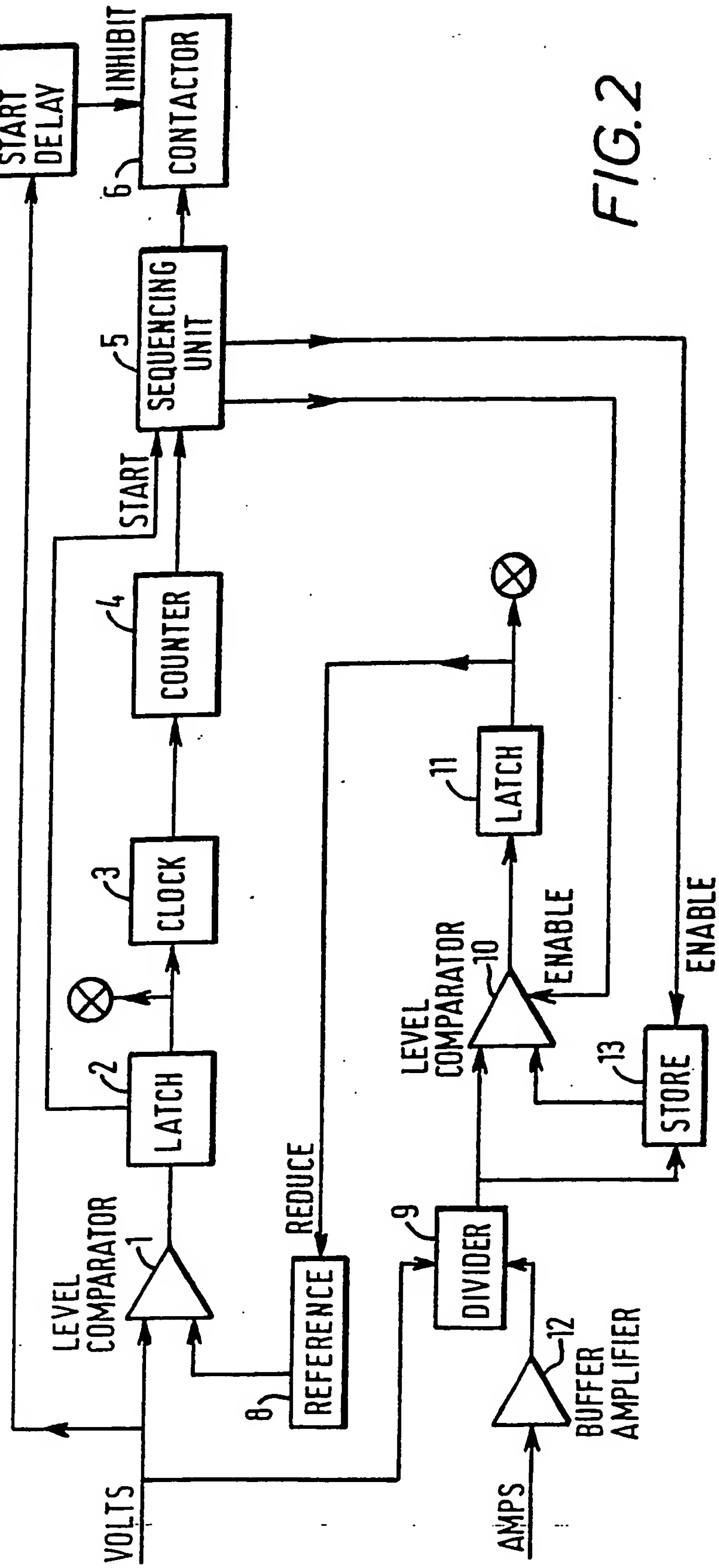

START DELAY
7
INHIBIT
CONTACTOR
6
SEQUENCING UNIT
5
START
COUNTER
4
CLOCK
3
LATCH
2
LEVEL COMPARATOR
1
REFERENCE
8
REDUCE
VOLTS
LATCH
11
LEVEL COMPARATOR
10
ENABLE
ENABLE
STORE
13
DIVIDER
9
BUFFER AMPLIFIER
12
AMPS

FIG.2

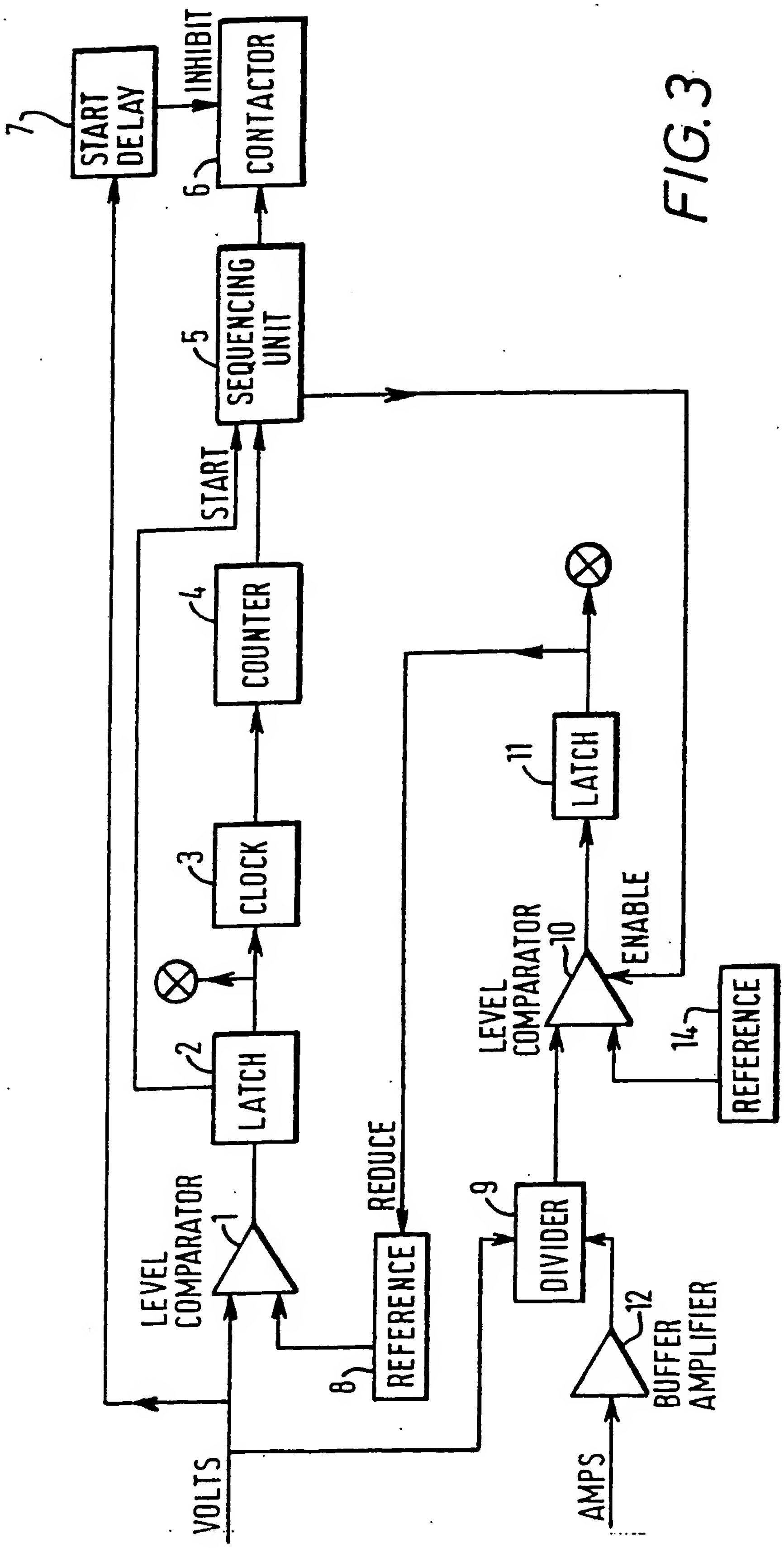

START DELAY
7
INHIBIT
CONTACTOR
6
SEQUENCING UNIT
5
START
COUNTER
4
CLOCK
3
LATCH
2
LEVEL COMPARATOR
1
REFERENCE
8
REDUCE
VOLTS
LATCH
11
LEVEL COMPARATOR
10
ENABLE
REFERENCE
14
DIVIDER
9
BUFFER AMPLIFIER
12
AMPS

FIG. 3

SPECIFICATION

## Battery Charging Apparatus

This invention relates to improvements in, or relating to, a method and apparatus for automatic battery charging, particularly, but not exclusively, for charging lead/acid traction batteries.

Normal taper chargers for lead/acid traction batteries provide an output characteristic such that 100% of the rated output current is provided at 2.1 volts per cell, the current tapering linearly to approximately 56% at 2.6 volts per cell. Typically, when the gassing voltage, approximately 2.37 volts per cell, is reached, a timer is started and charging is continued for a predetermined period, e.g. 3 hours, after which charging is terminated. Such charging systems take no account of battery age and condition and the present invention seeks to provide a method and apparatus for charging a re-chargeable battery which is responsive, during charging, to the internal condition (impedance) of the battery which is indicative of the actual state of charge.

According to one aspect of the present invention there is provided a method of charging a re-chargeable battery comprising the steps of firstly charging the battery in a first charging phase until the voltage of the battery reaches a predetermined level, measuring said voltage level and dividing this by the battery output current to provide an indication of battery impedance and entering the value of the battery impedance in a store, thereafter continuing the charging cycle in a second charging phase in which the value of battery impedance is monitored at predetermined intervals and the new value compared with the previous value held in the store, and then inserting the new value of impedance in the store, the periodic comparison being continued until the new value of impedance is more than a predetermined percentage of the previous value.

According to second aspect of the present invention there is provided a method of charging a rechargeable battery comprising the steps of firstly charging the battery in a first charging phase until the voltage of the battery rises to a predetermined level, measuring said voltage level and dividing this by the output current signal to provide an indication of battery impedance and comparing the impedance thus obtained with a predetermined fixed reference value, continuing the charging cycle in a second phase of charging and monitoring the battery impedance in the second phase, the second phase being terminated when the monitored impedance bears a predetermined relationship to the reference value. Preferably, the methods according to both aspects of the present invention also include an equalising charge, carried out after the completion of the second phase of charging, and this equalising charge may be described in our earlier Patent No. GB 1456226.

The invention also provides apparatus adapted to carry out the methods according to the invention. Preferred embodiments of the present invention will now be described by way of example with reference to the accompanying informal drawings in which:—

Figure 1 shows a basic rectification circuit for obtaining a DC output of the required level,

Figure 2 shows in block form, a control circuit for apparatus in accordance with the first aspect of the invention,

Figure 3 shows, in block diagram form, apparatus for carrying out the second aspect of the invention, and

Figure 4 shows a protection system which may be incorporated in the apparatus of Figures 2 or 3.

Figure 1 shows a known basic circuit for providing a DC output from an AC input. The AC output is supplied via a main contactor 20 to a reactive transformer 21, the output of which is supplied to a full wave reactifier, such as a bridge circuit 22 from which the DC output is obtained.

Referring now to Figure 2, this figure shows, in block diagram form, a control circuit for the charging current applied to a battery. The start of battery charging is delayed for a short period after battery connection by a start delay 7 which inhibits a contactor 6. After the initial delay a first charging phase is implemented and applied to the battery until a predetermined battery voltage is reached. Typically this voltage in a lead/acid traction battery is 2.37 volts per cell, the voltage at which gassing occurs. The circuit includes a voltage level comparator 1 which compares the actual battery voltage with a reference value 8 to terminate the first charging phase when the present voltage (usually 2.37 volts per cell) is reached.

When the first charging phase is terminated, a latch 2 is energised which starts a clock 3, a counter 4 and a sequencing unit 5. Also, at the end of the first charging phase, the apparent battery impedance is determined in a divider 9. The actual battery voltage is supplied to the divider 9 to which the battery output current signal is also supplied via a buffer amplifier 12 to provide an indication of the battery impedance. The battery impedance thus determined is entered and held in a store 13. Thereafter charging is continued in a second phase, and at regular intervals, which may be of 15 minutes duration, the instantaneous value of battery impedance is again determined by means of the divider 9, and the new value is compared with the previous value held in the store 13, by means of a comparator 10. The new value of impedance is then stored in the store 13, to replace the old value. This periodic comparison of the new value with the immediately preceding value is repeated until the new value of battery impedance is more than a predetermined percentage of the previous value. At this point a further latch 11 is energised to reduce the reference 8 and initiate a third phase of charging, an equalising charging cycle. This equalising charging phase may be as described in our earlier Patent No. 1456226.

A modification of the above sequencing procedure is shown in the modified embodiment

shown in block diagram form in Figure 3, where like references indicate like parts. This embodiment is essentially similar to the method and apparatus described with reference to Figure 2 except that in the second phase the battery impedance is continuously monitored and compared with a fixed reference. Thus, after the first phase of charging, the battery voltage is fed to the divider 9 as described with reference to Figure 2, as is the battery current output level which is connected to the divider through the buffer amplifier 12. The battery impedance thus determined is fed to the level comparator 10 which compares the impedance value with a predetermined value contained in a reference 14. Switching to the third phase of charging is effected when the monitored battery impedance is greater than the fixed value contained in the reference 14.

Figure 4 shows, again in block diagram form, a backup protection circuit which may be incorporated in the circuits shown in Figure 1 or 2 whereby the time spent in each phase of charging is monitored. A counter 15 is set to switch off the charging if the time in any one of the phases of charging exceeds a maximum value determined for that phase.

It will be appreciated that many variations may be made to the apparatus without departing from the scope of the invention, for example, a lower charging current may be provided for the second phase of charging, after the gassing voltage of 2.37 volts per cell has been reached by, for example, reducing the maximum current cycle from 100% to 70%. Also, provision may be made for automatic resetting of the system on battery removal or mains/supply failure. Also, various forms of semi-conductor, opto-electronic or electro-mechanical primary or secondary switching could be utilised in place of, or in conjunction with, the contactor 6.

**Claims**

1. A method of charging a re-chargeable battery comprising the steps of firstly charging the battery in a first charging phase until the voltage of the battery reaches a predetermined level, measuring said voltage level and dividing this by the battery output current to provide an indication of battery impedance and entering the value of the battery impedance in a store, thereafter continuing the charging cycle in a second charging phase in which the value of battery impedance is monitored at predetermined intervals and the new value compared to the previous value held in the store, and then inserting the new value of impedance in the store, the periodic comparison being continued until the new value of impedance is more than a predetermined percentage of the previous value.

2. A method of charging a battery as claimed in Claim 1, wherein the value of battery impedance is monitored at regular 15 minute intervals in the second phase.

3. A method of charging a rechargeable battery comprising the steps of firstly charging the battery in a first charging phase until the voltage of the battery reaches a predetermined level, measuring said voltage level and dividing this by the battery output current to provide an indication of the value of battery impedance and comparing the value of impedance thus obtained with a predetermined fixed reference value, continuing the charging cycle in a second phase of charging and monitoring the battery impedance in the second phase, the second phase being terminated when the monitored impedance bears a predetermined relationship to the reference value.

4. A method of charging a battery as claimed in Claim 3 wherein the battery impedance is monitored continuously in said second phase.

5. A method of charging a battery as claimed in any one of claims 1 to 4, wherein the charging current in the second phase is lower than the charging current in the first phase.

6. A method of charging a battery as claimed in any one of Claims 1 to 5 including a third equalising phase of charging carried out after the completion of the second phase.

7. A method of charging a battery as claimed in any one of Claims 1 to 6 including the step of monitoring the time spent in each phase of charging and terminating the charging if the time spent in any one of the phases is greater than a predetermined maximum value determined for that phase.

8. Apparatus for carrying out the method claimed in Claim 1 including a battery charger connectable to a battery to be charged and a control circuit including monitoring means comprising means to detect battery voltage level, a divider to divide the voltage level by the battery output current to provide a value for the battery impedance and a store for receiving the value of the battery impedance, timing means operable to initiate the monitoring means at predetermined intervals to obtain a new value of battery impedance and a comparator to compare the new value with the value held in the store, and means to insert the new value in the store.

9. Apparatus for carrying out the method claimed in Claim 3 including a battery charger connectable to a battery to be charged and a control circuit including, monitoring means comprising means to detect battery voltage level; a divider to divide battery voltage level by the battery output current to provide a value for the battery impedance, a comparator to compare the battery impedance thus obtained with a predetermined fixed reference value.

10. A method of charging a rechargeable battery substantially as described herein with reference to and as illustrated in Figures 1, 2 and 4 or Figures 1, 3 and 4 of the accompanying drawings.

11. Apparatus for charging a rechargeable

battery substantially as described herein with reference to and as illustrated in Figures 1, 2 and 4 or Figures 1, 3 and 4 of the accompanying drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1982. Published by the Patent Office.
25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.